Carbon, Nitrogen and Sulfur Isotope Content in Bull Kelp (*Nereocystis luetkeana*) Collected Within and Adjacent to Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site, Haida Gwaii, British Columbia, Canada

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CARBON, NITROGEN AND SULFUR ISOTOPE CONTENT IN BULL KELP (*Nereocystis luetkeana*) COLLECTED WITHIN AND ADJACENT TO GWAII HAANAS NATIONAL PARK RESERVE, NATIONAL MARINE CONSERVATION AREA RESERVE AND HAIDA HERITAGE SITE, HAIDA GWAII, BRITISH COLUMBIA, CANADA

by

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ABSTRACT

Stewart, H.L., Piercey, G.E., and Nomura, M. 2014. Carbon, nitrogen and sulfur isotope content in bull kelp (*Nereocystis luetkeana*) collected within and adjacent to Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site, Haida Gwaii, British Columbia, Canada. Can. Data Rep. Fish. Aquat. Sci. 1253: iv + 11 p.

Carbon, nitrogen and sulfur isotopes were analyzed from tissue samples of bull kelp (*Nereocystis luetkeana*) collected from 12 sites in Haida Gwaii, British Columbia. The data are expected to serve as a baseline for future nutrient cycling studies in the area, and may help with the evaluation of conservation and management policies for the Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and rockfish conservation areas (RCAs).

RÉSUMÉ

Stewart, H. L., Piercey, G. E. et Nomura, M. 2014. Contenu en isotopes de soufre, d'azote et de carbone de la nereocystis de Lutke (*Nereocystis luetkeana*) recueillie à l'intérieur et à proximité de la Réserve de parc national, de la réserve d'aire marine nationale de conservation, et du site du patrimoine haïda Gwaii Haanas, Haida Gwaii (Colombie-Britannique) Canada. Rapp. stat. can. sci. halieut. aquat. 1253 : iv + 11 p.

Les auteurs ont analysé les isotopes de soufre, d'azote et de carbone dans les échantillons de tissus de la nereocystis de Lutke (*Nereocystis luetkeana*) recueillie à douze emplacements à Haida Gwaii, en Colombie-Britannique. Les données devraient servir de point de départ pour les prochaines études sur le cycle des éléments nutritifs dans la région et pourraient aider à l'évaluation des politiques de conservation et de gestion pour la Réserve de parc national et la réserve d'aire marine nationale de conservation Gwaii Haanas ainsi que les aires de conservation du sébaste (ACS).

INTRODUCTION

As part of the baseline ecosystem study conducted between 2009 and 2013 at the Gwaii Haanas National Marine Conservation Area Reserve (NMCAR) and associated rockfish conservation areas (RCAs) described by Trebilco et al. (2014), samples of bull kelp (*Nereocystis luetkeana*) collected in the summer of 2013 were taken and set aside for nutrient analysis.

Naturally occurring isotopes of carbon, nitrogen and sulfur tend to maintain their ratios as they cycle through a local ecosystem (Peterson and Fry 1987). Stable isotope ratios in kelp can vary according to various factors such as tidal gradient (Cooper and McCroy 1988), season and age (Frederiksen 2003, Dethier et al. 2013); however, ratios of multiple stable isotopes such as ^{13}C:^{15}N remain distinct for each species (Dethier et al. 2013). Thus it is possible to trace the flow of nutrients from primary producers such as *N. luetkeana* through the food chain (Hesslein et al. 1991, Ramshaw 2012, Fry 2013). Of particular interest, here on the British Columbia coast, may be the relationship between kelp, sea urchin and sea otters (Rodriguez 2003, Vanderklift et al. 2006, Ramshaw 2012).

METHODS

Study sites and sampling method

Bull kelp (*Nereocystis luetkeana*) samples were collected between July 15 and August 1 of 2013 from 12 monitoring sites as described by Trebilco et al. 2014 (Figure 1 and Table 1). A tissue sample from individual plants was cut from the blade approximately 15 cm above the bulb. These were placed in individually labeled Ziploc bags and frozen at -5°C in the field.

Nutrient analysis

In the laboratory, up to 10 samples from each site were dried for a minimum of 48 hours at 50 °C in a Sheldon Manufacturing Inc. Model 1305U oven. The samples were then ground in a mortar and pestle, and then ground further into a fine powder using a Rinn Crescent Wig-L-Bug MSD Amalgamator fitted with a stainless steel ball and polymeric vial. Five milligram aliquots were measured out using a Sartorius CPA225D analytical balance, and shipped to the University of California, Davis Stable Isotope Facility for carbon, nitrogen and sulfur isotope analyses.

Carbon and nitrogen were analyzed from a single sample using a PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK). The results were presented relative to international standards V-PDB (Vienna PeeDee Belemnite) for carbon, and air for nitrogen. Sulfur was analyzed with an Elementar vario ISOTOPE cube interfaced to a SerCon 20-22 IRMS (Sercon Ltd., Cheshire, UK), and these results were presented relative to VCDT (Vienna Canyon Diablo Troilite) standards. For details see http://stableisotopefacility.ucdavis.edu/.

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Figure 1. Locations of monitoring sites. Black points indicate monitoring sites. The Gwaii Haanas National Marine Conservation Area Reserve (NMCAR) and Rockfish Conservation Areas (RCAs) are indicated.

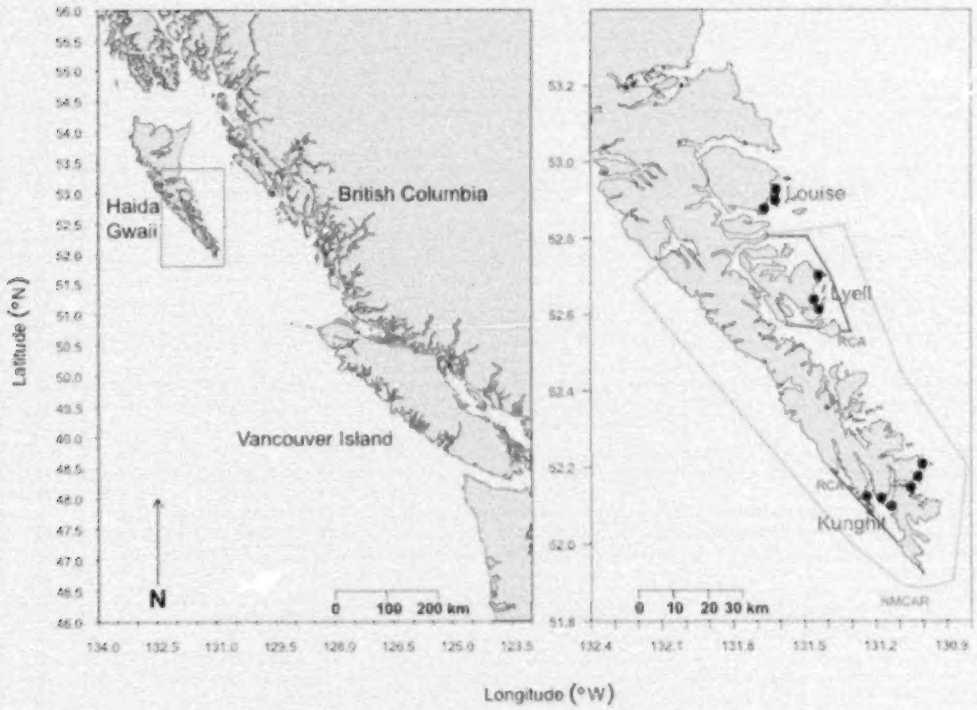

Table 1. Names, locations and management policy of monitoring sites. RCA = Rockfish Conservation Area, NMCAR = National Marine Conservation Area Reserve.

Area	Management policy	Site	Latitude	Longitude
Louise	Commercial Red Urchin Fishery Closure	Skedans	52.9258° N	131.6175° W
		Vertical	52.8983° N	131.6259° W
		Nelson	52.8757° N	131.6719° W
Lyell	Commercial Red Sea Urchin Fishery Closure, RCA, NMCAR	Fuller	52.7102° N	131.4430° W
		Lyell SE	52.6427° N	131.4391° W
		Murchison	52.6157° N	131.4346° W
Kunghit E	NMCAR	Benjamin	52.2128° N	130.9963° W
		Koya	52.1799° N	131.0128° W
		Moorehead	52.1442° N	131.0467° W
Kunghit W	RCA, NMCAR	Louscoone	52.1291° N	131.2283° W
		Fanny	52.1191° N	131.1776° W
		Arnold	52.0987° N	131.1257° W

Table 2. Carbon and nitrogen content in bull kelp tissue samples. $\delta^{13}C$ and $\delta^{15}N$ are ratios calculated relative to V-PDB (Vienna PeeDee Belemnite) and air, respectively. Sample mean and standard error are shown.

Area	Site	n	Sample (mg)	C (ug)	N (ug)	%C	%N	C:N ratio	$\delta^{13}C$	$\delta^{15}N$
Louise	Skedans 1		4.74	1775.59	163.03	37.5	3.44	10.9	-17.74	6.69
	Skedans 2		5.38	2023.61	213.04	37.6	3.96	9.5	-19.47	6.28
	Skedans 3		5.01	1759.06	163.03	35.1	3.25	10.8	-17.30	6.49
	Skedans 4		5.54	1940.93	170.11	35.0	3.07	11.4	-16.14	8.31
	Skedans 5		5.40	1924.40	195.80	35.6	3.63	9.8	-17.54	6.91
	Skedans 6		5.41	1858.26	173.64	34.3	3.21	10.7	-18.85	6.40
	Skedans 7		4.82	1709.46	155.91	35.5	3.23	11.0	-16.54	7.39
	Skedans 8		5.12	1709.46	151.14	33.4	2.95	11.3	-16.59	6.86
	Skedans 9		5.42	1940.93	191.16	35.8	3.53	10.2	-17.23	6.63
	Skedans 10		5.22	1825.19	163.03	35.0	3.12	11.2	-17.95	6.77
	$\bar{x} \pm SE$	**10**	**5.21 ± 0.09**	**1846.69 ± 34.33**	**173.99 ± 6.25**	**35.48 ± 0.41**	**3.34 ± 0.10**	**10.67 ± 0.20**	**-17.53 ± 0.33**	**6.87 ± 0.19**
	Vertical 1		5.40	1940.93	183.02	35.9	3.39	10.6	-18.73	7.17
	Vertical 2		5.36	1907.86	186.51	35.6	3.48	10.2	-19.32	5.88
	Vertical 3		4.96	1808.66	159.47	36.5	3.22	11.3	-18.34	8.60
	Vertical 4		5.22	1602.00	139.16	30.7	2.67	11.5	-17.87	8.91
	Vertical 5		5.05	1436.68	119.91	28.4	2.37	12.0	-18.63	8.25
	Vertical 6		5.06	1621.84	145.16	32.1	2.87	11.2	-17.97	8.92
	Vertical 7		5.48	1542.48	148.75	28.1	2.71	10.4	-19.20	7.29
	Vertical 8		5.20	1603.65	148.75	30.8	2.86	10.8	-19.18	7.15
	Vertical 9		5.23	1431.72	118.44	27.4	2.26	12.1	-18.45	8.57
	$\bar{x} \pm SE$	**9**	**5.22 ± 0.06**	**1655.09 ± 63.03**	**149.91 ± 7.96**	**31.73 ± 1.18**	**2.87 ± 0.14**	**11.12 ± 0.22**	**-18.63 ± 0.18**	**7.86 ± 0.35**
	Nelson 1		5.24	1775.59	143.96	33.9	2.75	12.3	-17.99	8.34
	Nelson 2		5.13	1676.39	124.65	32.7	2.43	13.4	-16.95	8.69
	Nelson 3		4.84	1692.93	142.76	35.0	2.95	11.9	-18.86	8.22
	Nelson 4		5.14	1759.06	147.56	34.2	2.87	11.9	-20.27	6.92
	Nelson 5		5.44	1874.80	145.16	34.5	2.67	12.9	-16.56	8.88
	Nelson 6		5.10	1568.93	123.56	30.8	2.42	12.7	-17.40	8.61
	Nelson 7		4.90	1606.96	123.07	32.8	2.51	13.1	-17.05	8.79
	Nelson 8		5.24	1725.99	133.13	32.9	2.54	13.0	-16.75	9.02
	Nelson 9		4.87	1592.08	140.36	32.7	2.88	11.3	-15.82	8.96
	Nelson 10		5.18	1449.90	112.33	28.0	2.17	12.9	-18.37	8.65
	$\bar{x} \pm SE$	**10**	**5.11 ± 0.06**	**1672.26 ± 38.50**	**133.65 ± 3.81**	**32.74 ± 0.65**	**2.62 ± 0.08**	**12.54 ± 0.21**	**-17.60 ± 0.41**	**8.51 ± 0.19**

Table 2 (Continued). Carbon and nitrogen content in bull kelp tissue samples.

Area	Site	n	Sample (mg)	C (ug)	N (ug)	%C	%N	C:N ratio	$\delta^{13}C$	$\delta^{15}N$
	Fuller 1		4.96	1709.46	143.96	34.5	2.90	11.9	-18.92	7.55
	Fuller 2		4.75	1562.32	128.29	32.9	2.70	12.2	-17.41	7.77
	Fuller 3		4.72	1621.84	136.75	34.4	2.90	11.9	-18.36	6.73
	Fuller 4		5.44	1709.46	137.95	31.4	2.54	12.4	-19.33	6.75
	Fuller 5		5.39	1792.13	153.53	33.2	2.85	11.7	-19.10	6.69
	Fuller 6		5.55	1656.55	173.64	29.8	3.13	9.5	-21.82	5.51
	Fuller 7		5.00	1327.57	111.23	26.6	2.22	11.9	-18.00	7.52
	Fuller 8		4.87	1461.48	121.98	30.0	2.50	12.0	-18.80	7.20
	Fuller 9		5.48	1595.38	134.34	29.1	2.45	11.9	-19.94	6.77
	Fuller 10		5.14	1598.69	148.75	31.1	2.89	10.7	-19.86	5.42
	$\bar{x} \pm SE$	**10**	**5.13 ± 0.10**	**1603.49 ± 42.07**	**139.04 ± 5.51**	**31.30 ± 0.79**	**2.71 ± 0.09**	**11.61 ± 0.27**	**-19.15 ± 0.39**	**6.79 ± 0.25**
	Lyell SE 1		5.40	1759.06	153.53	32.6	2.84	11.5	-15.81	7.63
	Lyell SE 2		5.02	1725.99	146.36	34.4	2.92	11.8	-16.80	7.17
	Lyell SE 3		5.01	1825.19	166.58	36.4	3.32	11.0	-16.38	7.67
	Lyell SE 4		5.31	1759.06	146.36	33.1	2.76	12.0	-16.67	7.84
	Lyell SE 5		5.25	1742.53	152.33	33.2	2.90	11.4	-16.97	7.77
Lyell	Lyell SE 6		4.73	1759.06	154.72	37.2	3.27	11.4	-14.76	8.12
	Lyell SE 7		5.31	1841.73	148.75	34.7	2.80	12.4	-15.27	7.93
	Lyell SE 8		5.18	1709.46	140.36	33.0	2.71	12.2	-14.89	7.99
	Lyell SE 9		5.41	1759.06	147.56	32.5	2.73	11.9	-14.57	8.29
	Lyell SE 10		5.51	1858.26	166.58	33.7	3.02	11.2	-17.66	7.42
	$\bar{x} \pm SE$	**10**	**5.21 ± 0.07**	**1773.94 ± 15.87**	**152.31 ± 2.71**	**34.08 ± 0.51**	**2.93 ± 0.07**	**11.67 ± 0.15**	**-15.98 ± 0.34**	**7.78 ± 0.10**
	Murchison 1		5.12	1626.79	129.50	31.8	2.53	12.6	-17.11	7.85
	Murchison 2		5.38	1775.59	139.16	33.0	2.59	12.8	-16.31	6.75
	Murchison 3		5.28	1841.73	155.91	34.9	2.95	11.8	-17.54	6.41
	Murchison 4		5.18	1841.73	148.75	35.6	2.87	12.4	-17.30	7.69
	Murchison 5		5.31	1725.99	145.16	32.5	2.73	11.9	-18.43	7.71
	Murchison 6		5.42	1907.86	168.94	35.2	3.12	11.3	-18.47	7.15
	Murchison 7		5.24	1611.92	140.36	30.8	2.68	11.5	-20.00	7.51
	Murchison 8		4.72	1552.40	128.29	32.9	2.72	12.1	-16.72	6.54
	Murchison 9		5.12	1725.99	142.76	33.7	2.79	12.1	-16.99	6.38
	Murchison 10		5.17	1742.53	152.33	33.7	2.95	11.4	-19.75	5.92
	$\bar{x} \pm SE$	**10**	**5.19 ± 0.06**	**1735.25 ± 35.70**	**145.12 ± 3.86**	**33.40 ± 0.48**	**2.79 ± 0.06**	**11.98 ± 0.16**	**-17.86 ± 0.40**	**6.99 ± 0.21**

Table 2 (Continued). Carbon and nitrogen content in bull kelp tissue samples.

Area	Site	n	Sample (mg)	C (ug)	N (ug)	%C	%N	C:N ratio	$\delta^{13}C$	$\delta^{15}N$
	Benjamin 1		5.38	1924.40	157.10	35.8	2.92	12.2	-19.89	5.79
	Benjamin 2		5.36	2023.61	224.42	37.8	4.19	9.0	-22.47	5.51
	Benjamin 3		5.40	1858.26	210.76	34.4	3.90	8.8	-23.58	5.28
	Benjamin 4		5.09	1891.33	191.16	37.2	3.76	9.9	-24.07	4.91
	Benjamin 5		4.97	1825.19	179.51	36.7	3.61	10.2	-22.00	5.78
	Benjamin 6		5.31	1907.86	183.02	35.9	3.45	10.4	-21.05	5.38
	Benjamin 7		5.36	1990.54	168.94	37.1	3.15	11.8	-19.52	4.18
	Benjamin 8		5.40	1957.47	200.42	36.2	3.71	9.8	-21.98	5.51
	Benjamin 9		4.74	1656.55	141.56	34.9	2.99	11.7	-18.70	4.71
	Benjamin 10		5.19	1742.53	141.56	33.6	2.73	12.3	-19.58	5.19
	$\bar{x} \pm SE$	**10**	**5.22 ± 0.07**	**1877.77 ± 35.59**	**179.84 ± 8.86**	**35.97 ± 0.42**	**3.44 ± 0.15**	**10.61 ± 0.41**	**-21.29 ± 0.58**	**5.22 ± 0.16**
	Koya 1		5.52	2023.61	217.61	36.7	3.94	9.3	-22.52	5.47
	Koya 2		4.83	1623.49	171.29	33.6	3.55	9.5	-23.39	6.05
	Koya 3		5.03	1676.39	146.36	33.3	2.91	11.5	-22.05	5.72
	Koya 4		5.05	1725.99	170.11	34.2	3.37	10.1	-21.92	5.96
Kunghit E	Koya 5		5.42	1907.86	185.35	35.2	3.42	10.3	-21.98	5.07
	Koya 6		4.64	1383.78	142.76	29.8	3.08	9.7	-22.57	6.60
	Koya 7		5.15	1709.46	153.53	33.2	2.98	11.1	-21.47	5.27
	Koya 8		5.46	1676.39	165.39	30.7	3.03	10.1	-21.58	6.41
	$\bar{x} \pm SE$	**8**	**5.14 ± 0.11**	**1715.87 ± 67.30**	**169.05 ± 8.55**	**33.34 ± 0.79**	**3.28 ± 0.12**	**10.20 ± 0.27**	**-22.19 ± 0.22**	**5.82 ± 0.19**
	Moorehead 1		5.35	2007.07	181.85	37.5	3.40	11.0	-18.09	5.99
	Moorehead 2		4.93	1825.19	177.17	37.0	3.59	10.3	-19.86	6.17
	Moorehead 3		5.34	1924.40	177.17	36.0	3.32	10.9	-18.26	6.40
	Moorehead 4		5.43	2007.07	188.84	37.0	3.48	10.6	-19.36	3.62
	Moorehead 5		5.24	1552.40	137.95	29.6	2.63	11.3	-17.75	5.36
	Moorehead 6		5.21	1573.89	139.16	30.2	2.67	11.3	-16.10	6.31
	Moorehead 7		5.39	1588.77	142.76	29.5	2.65	11.1	-18.78	5.99
	Moorehead 8		5.40	1578.85	139.16	29.2	2.58	11.3	-16.43	6.16
	Moorehead 9		5.02	1387.08	125.62	27.6	2.50	11.0	-17.09	6.22
	Moorehead 10		5.02	1418.49	128.29	28.3	2.56	11.1	-16.99	5.84
	$\bar{x} \pm SE$	**10**	**5.23 ± 0.06**	**1686.32 ± 74.14**	**153.80 ± 7.71**	**32.20 ± 1.30**	**2.94 ± 0.14**	**11.00 ± 0.10**	**-17.87 ± 0.39**	**5.81 ± 0.26**

Table 2 (Continued). Carbon and nitrogen content in bull kelp tissue samples.

Area	Site	n	Sample (mg)	C (ug)	N (ug)	% C	% N	C:N ratio	$\delta^{13}C$	$\delta^{15}N$
	Louscoone 1		5.51	1808.66	154.72	32.83	2.81	11.69	-19.79	5.19
	Louscoone 2		5.15	1676.39	180.68	32.55	3.51	9.28	-23.08	5.95
	Louscoone 3		4.71	1479.66	130.71	31.42	2.78	11.32	-19.53	5.84
	Louscoone 4		4.90	1497.84	149.95	30.57	3.06	9.99	-21.00	6.59
	Louscoone 5		4.75	1421.80	136.75	29.93	2.88	10.40	-21.17	4.88
	Louscoone 6		5.45	1709.46	149.95	31.37	2.75	11.40	-20.45	5.21
	$\bar{x} \pm SE$	**6**	**5.08 ± 0.14**	**1598.97 ± 62.72**	**150.46 ± 7.09**	**31.44 ± 0.45**	**2.96 ± 0.12**	**10.68 ± 0.39**	**-20.84 ± 0.52**	**5.61 ± 0.26**
	Fanny 1		4.96	1426.76	123.31	28.77	2.49	11.57	-16.59	8.25
	Fanny 2		5.54	1676.39	158.29	30.26	2.86	10.59	-19.18	7.52
	Fanny 3		5.24	1527.60	134.34	29.15	2.56	11.37	-16.57	8.11
	Fanny 4		5.23	1358.98	116.49	25.98	2.23	11.67	-15.96	8.80
	Fanny 5		4.91	1299.47	108.78	26.47	2.22	11.95	-18.65	8.00
	Fanny 6		5.45	1375.51	111.97	25.24	2.05	12.29	-16.21	8.00
	Fanny 7		5.27	1527.60	146.36	28.99	2.78	10.44	-18.97	7.82
Kunghit W	Fanny 8		5.59	1676.39	147.56	29.99	2.64	11.36	-18.27	7.76
	Fanny 9		5.48	1373.86	114.05	25.07	2.08	12.05	-16.80	7.88
	Fanny 10		4.95	1651.59	154.72	33.37	3.13	10.67	-20.59	6.28
	$\bar{x} \pm SE$	**10**	**5.26 ± 0.08**	**1489.42 ± 45.03**	**131.58 ± 6.00**	**28.33 ± 0.83**	**2.50 ± 0.11**	**11.39 ± 0.20**	**-17.78 ± 0.49**	**7.84 ± 0.20**
	Arnold 1		4.75	1692.93	139.16	35.6	2.93	12.2	-19.69	4.08
	Arnold 2		5.12	1891.33	157.10	36.9	3.07	12.0	-19.42	5.28
	Arnold 3		4.85	1676.39	134.34	34.6	2.77	12.5	-18.97	6.22
	Arnold 4		5.51	1858.26	158.29	33.7	2.87	11.7	-19.48	5.67
	Arnold 5		5.23	1709.46	136.75	32.7	2.61	12.5	-18.91	6.92
	Arnold 6		5.11	1742.53	142.76	34.1	2.79	12.2	-20.31	5.55
	Arnold 7		4.96	1405.27	121.12	28.3	2.44	11.6	-21.07	6.27
	Arnold 8		5.42	1507.76	134.34	27.8	2.48	11.2	-18.70	7.37
	Arnold 9		5.33	1742.53	152.33	32.7	2.86	11.4	-19.26	5.21
	Arnold 10		5.06	1522.64	128.29	30.1	2.54	11.9	-19.75	6.58
	$\bar{x} \pm SE$	**10**	**5.13 ± 0.08**	**1674.91 ± 48.87**	**140.45 ± 3.88**	**32.66 ± 0.96**	**2.74 ± 0.07**	**11.93 ± 0.14**	**-19.56 ± 0.22**	**5.92 ± 0.30**

Table 3. Sulfur content in bull kelp tissue samples. $\delta^{34}S$ was calculated relative to the VCDT (Vienna Canyon Diablo Troilite) standard. Sample mean and standard error are shown.

Area	Site	n	Sample (mg)	S (µg)	‰ S	$\delta^{34}S$ vs. VCDT
Louise	Skedans 1		2.38	22.80	9.58	21.51
	Skedans 2		2.51	31.72	12.64	21.99
	Skedans 3		2.13	22.33	10.49	21.11
	$\bar{x}$ ± SE	**3**	**2.34 ± 0.11**	**25.62 ± 3.05**	**10.90 ± 0.91**	**21.54 ± 0.35**
	Vertical 1		1.55	21.98	14.18	21.36
	Vertical 2		2.13	23.30	10.94	21.32
	Vertical 3		2.52	33.26	13.20	21.83
	$\bar{x}$ ± SE	**3**	**2.07 ± 0.28**	**26.18 ± 3.56**	**12.77 ± 0.96**	**21.51 ± 0.16**
	Nelson 1		2.51	31.42	12.52	21.67
	Nelson 2		2.47	27.93	11.31	21.83
	Nelson 3		1.57	19.41	12.36	21.63
	$\bar{x}$ ± SE	**3**	**2.18 ± 0.31**	**26.25 ± 3.57**	**12.06 ± 0.38**	**21.71 ± 0.06**
Lyell	Fuller 1		2.09	21.53	10.30	20.27
	Fuller 2		2.39	27.99	11.71	20.37
	Fuller 3		2.35	23.41	9.96	20.29
	$\bar{x}$ ± SE	**3**	**2.28 ± 0.09**	**24.31 ± 1.92**	**10.66 ± 0.54**	**20.31 ± 0.03**
	Lyell SE 1		1.95	21.20	10.87	20.48
	Lyell SE 2		2.45	28.53	11.64	21.45
	Lyell SE 3		2.49	30.07	12.08	21.58
	$\bar{x}$ ± SE	**3**	**2.30 ± 0.17**	**26.60 ± 2.74**	**11.53 ± 0.35**	**21.17 ± 0.35**
	Murchison 1		1.86	20.53	11.04	21.35
	Murchison 2		2.14	22.85	10.68	21.65
	Murchison 3		2.15	25.63	11.92	21.54
	$\bar{x}$ ± SE	**3**	**2.05 ± 0.10**	**23.00 ± 1.47**	**11.21 ± 0.37**	**21.51 ± 0.09**

Table 3 (Continued). Sulfur content in bull kelp tissue samples.

Area	Site	n	Sample (mg)	S (µg)	‰ S	$\delta^{34}S$ vs. VCDT
Kunghit E	Benjamin 1		1.68	17.28	10.29	21.06
	Benjamin 2		2.51	27.51	10.96	21.29
	Benjamin 3		2.47	29.17	11.81	21.26
	$\bar{x}$ ± SE	**3**	**2.22 ± 0.27**	**24.65 ± 3.72**	**11.02 ± 0.44**	**21.20 ± 0.07**
	Koya 1		2.2	20.73	9.42	19.94
	Koya 2		2.51	29.49	11.75	20.45
	Koya 3		2.42	32.16	13.29	21.18
	$\bar{x}$ ± SE	**3**	**2.38 ± 0.09**	**27.46 ± 3.45**	**11.49 ± 1.12**	**20.52 ± 0.36**
	Moorehead 1		2.46	21.14	8.59	21.51
	Moorehead 2		2.25	21.27	9.45	21.22
	Moorehead 3		2.24	21.05	9.40	21.60
	$\bar{x}$ ± SE	**3**	**2.32 ± 0.07**	**21.15 ± 0.07**	**9.15 ± 0.28**	**21.44 ± 0.11**
Kunghit W	Louscoone 1		2.64	26.40	10.00	20.25
	Louscoone 2		2.53	26.48	10.47	20.16
	Louscoone 3		2.00	21.96	10.98	19.83
	$\bar{x}$ ± SE	**3**	**2.39 ± 0.20**	**24.95 ± 1.49**	**10.48 ± 0.28**	**20.08 ± 0.13**
	Fanny 1		2.44	23.46	9.61	18.92
	Fanny 2		2.13	20.50	9.63	19.68
	Fanny 3		1.95	18.73	9.61	19.62
	$\bar{x}$ ± SE	**3**	**2.17 ± 0.14**	**20.90 ± 1.38**	**9.61 ± 0.01**	**19.40 ± 0.24**
	Arnold 1		1.56	13.97	8.95	21.50
	Arnold 2		2.15	19.93	9.27	21.55
	Arnold 3		1.86	18.50	9.94	21.47
	$\bar{x}$ ± SE	**3**	**1.86 ± 0.17**	**17.47 ± 1.80**	**9.39 ± 0.29**	**21.51 ± 0.02**